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Materiel Test Procedure 6-2-030
Electronic Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

BEACON DEVICES, ELECTRONIC

1. OBJECTIVE

The objective of the procedures outlined in this MTP is to provide a means of evaluating the technical performance and technical characteristics of electronic beacon devices, and determining their suitability for an intended use.

2. BACKGROUND

The general term "beacon" has been applied to various signal devices in the past, but the electronic beacons is a relatively recent development which utilizes electromagnetic radiation and is continuing to be improved with the electronic art. These recently developed electronic signal devices are often referred to as radio beacons or radar beacons. Such designations refer only to the frequency ranges of the devices, however, and do not indicate essentially different items.

Electronic beacon devices have many purposes. They may be used to identify a definite location, indicate a bearing for navigation, transmit and identification signal (usually coded), or provide signal strength to ensure reception of track data at greater ranges. Beacons are often used in triangulation for various purposes and to provide communication channels.

Beacon devices operate in one or more transmission modes. They may transmit continuously, or on an intermittent schedule, or they may remain passive until triggered by a signal sent for that purpose.

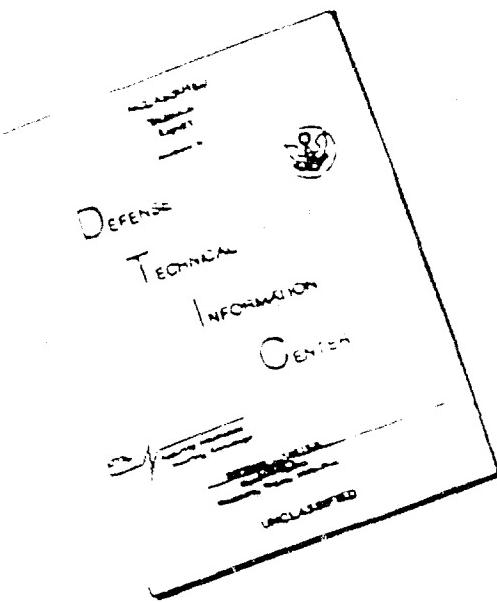
One of the more important uses of beacon devices, militarily, is in the identification of friendly targets (usually aircraft) in a surveillance zone. This process is known as Identification of Friend or Foe (IFF). The use of beacons in such a manner makes it unnecessary to investigate all approaching targets indiscriminately, thus conserving the strength of defensive systems. IFF devices carried by cooperative craft emit a coded response when interrogated or challenged by a suitable transmitter, or when activated by the user.

IFF equipment consists of a radar system with two parts: (1) an interrogator-responsor unit, and (2) a transponder subsystem. The first part transmits a signal to a transponder located on the target. The coded reply from the transponder is received back at the interrogator and displayed on a PPI in a manner similar to an ordinary radar echo.

The importance of the equipment mission indicates the need for engineering tests of all electronic beacon equipment to ensure that it meets applicable requirements and has the specialized characteristics necessary for its intended use.

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3. REQUIRED EQUIPMENT

- a. Radio receiver
- b. Radar test set (may be a component of test item)
- c. Frequency counter or meter
- d. Oscilloscope (CRT type)
- e. Automatic-gain-control voltmeter
- f. Field intensity meter
- g. Synchroscope
- h. Pulse-signal generator
- i. Test oscillator
- j. Frequency transfer-standard
- k. Voltage divider
- l. Dummy load
- m. Tube tester; Transistor tester
- n. Automatic recorders
- o. Receiver-Indicator
- p. Signal attenuator
- q. Extra transponder
- r. Camera with scope adapter
- s. Instrumented Test Range
- t. Appropriate aviation support

4. REFERENCES

- A. Radar Beacons, Radiation Lab Series, Vol III, 1947.
- B. Skolnik, Merril I., Introduction to Radar Systems, McGraw-Hill, 1962.
- C. MIL-C-3098, Crystal Unit, General Specifications For.
- D. MIL-STD-449-C, Radio Frequency Spectrum Characteristics, 1965.
- E. MIL-E-5400, Electronic Equipment, General Specifications For.
- F. MIL-R-26667, Reliability and Longevity Requirements, Electronics Equipment.
- G. MIL-STD-781, Tests Levels and Criteria for Electronic Equipment, 1963.
- H. MIL-STD-810B, Environmental Test Methods.
- I. SM Sig 7 and 8, Beacon AN/CVX-1.
- J. TM 11-5046, Homing Beacon AN/CRN-12.
- K. TM-11-5895-217-35, Transponder Set AN/APX-44.
- L. TM 11-5895-252-12, Transponder Set AN/DPN-62(V).
- M. MTP 6-2-020, Radar Antenna Subsystem Tests
- N. MTP 6-2-515, Transmitter Range Tests.
- O. MTP 6-2-514, Electrical Power Requirements
- P. MTP 6-2-210, Power Supply, Electrical
- Q. MTP 6-2-508, Electromagnetic Vulnerability
- R. MTP 6-2-509, Electromagnetic Compatibility
- S. MTP 6-2-517, Frequency Accuracy and Stability.
- T. MTP 6-2-242, Receivers- Transmitters, General.

5. SCOPE

5.1 SUMMARY

5.1.1 Technical Characteristics

The procedures outlined in this MTP provide general guidance for evaluating the technical performance and technical characteristics of a category of communications equipment described as "electronic beacon devices", (to include transponders and IFF equipment) and determining their suitability for an intended use.

The specific tests to be performed, along with their intended objectives, are listed below:

a. Electromagnetic Field Pattern - The objective of this test is to determine the test item's directional characteristics (or in special cases, the concentration of radiation in specified directions).

b. Transmission Range - The objective of this test is to determine maximum and optimum ranges of transmission for the test item when the receiver or detector is designed for used with the beacon being tested.

c. Power Requirement - The objective of this test is to determine

- 1) The amount of energy input necessary for the test item to achieve its mission.
- 2) The effects of an unstable or variable power supply

d. Power Supply - The objective of this test is to determine capacity, capability, and probable life of the power supply provided for the test item.

e. Electromagnetic Vulnerability - The objective of this test is to determine if the test item exhibits.

- 1) Reactions to alien transmissions in an electromagnetic environment
- 2) Undesirable reactions

f. Electromagnetic Capability - The objective of this test is to determine the capability of the test item to operate in an electromagnetic Environment without producing interference or overriding signals to other systems.

g. Spectrum Signature - The objective of this test is to determine the frequencies included in the transmitted radiations and the spectral bandwidth of the test item.

h. Frequency Accuracy and Stability - The objective of this test is to determine variations in the signal frequency of the test item and the number of such variations versus time.

i. Interrogator Transmitter and Receiver - The objective of this test is to determine the technical characteristics of the interrogator transmitter and receiver, and to ensure that they are operating in accordance with appropriate specifications.

j. Bench Tests - The objective of these tests is to determine the technical and operational characteristics of the component circuitry of the test item to include:

- 1) Voltage
- 2) Local Oscillator Automatic Frequency Control (AFC)
- 3) Pulse Length Discriminator
- 4) Coder
- 5) Quartz Crystal Units
- 6) Magnetron Current
- 7) Sensitivity
- 8) Overall Check

k. Triggering System - The objective of this test is to determine characteristics of the trigger mechanism. If this mechanism is the self-actuated type, the timing and pulse rate shall be determined. If it is actuated remotely, the response time, the freedom of action after extended periods of inactivity, and the dependence upon a reliable power level shall be included.

l) Coding System - The objective of this test is to:

- a) Determine the characteristics of the coding system
- b) Evaluate the response pattern

NOTE: This shall include coded responses (if used), action in response to coded signals, and refusal to respond to uncoded signals or to spurious signals.

m. Transponder Tests - The objective of these tests is to determine the technical characteristics of the transponder component.

n. Interrogation Subsystem Test - The objective of these is to determine the technical characteristics of the interrogator-resonser subsystem as an integrated entity.

o. IFF System Test - The objective of this test is to determine the technical performance of the IFF test item in operation as a functional system.

5.1.2 Common Engineering Tests

Not included in this MTP are the following common engineering tests which apply to this commodity:

- a. 6-2-500, Physical Characteristics
- b. 6-2-502, Human Factors Engineering
- c. 6-2-503, Reliability
- d. 6-2-504, Design for Maintainability
- e. 6-2-507, Safety

5.2 LIMITATIONS

The variety of electronic beacon devices which this MTP is applicable, precludes detailed coverage of any particular item. The testing methods outlined are intentionally general to provide test coverage for various electronic beacon systems and may be adapted, as necessary, to accommodate specific equipment.

6. PROCEDURES

6.1 PREPARATION FOR TEST

- a. Select test equipment having an accuracy of at least ten times greater than that of the function to be measured.
- b. Record the following information:
 - 1) Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.
 - 2) Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the test.
- c. Ensure that all test personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in Qualitative materiel requirements (QMR), Small Development Requirements (SDR), and Technical Characteristics (TC).
- d. Review all instructional material issued with the test item by the manufacturer, contractor, or government, as well as reports of previous tests conducted on the same types of equipment, and familiarize all test personnel with the contents of such documents. These documents shall be kept readily available for reference.
- e. Prepare record forms for systematic entry of data, chronology of test, and analysis in final evaluation of the test item.
- f. Prepare adequate safety precautions to provide safety for personnel and equipment, ensure that all safety SOP's are observed throughout the test, and that the item has successfully completed MTP 6-2-507, Safety.
- g. Thoroughly inspect the test item for obvious physical and electrical defects such as cracked or broken parts, loose connections, bare or broken wires, loose assemblies, bent fragile parts, and corroded plugs and jacks. Perform interior inspection for inoperative blowers and controls, loose or broken components, and other obvious damage. Inspect fuzes to verify that ratings are in agreement with designated values. All defects shall be noted and corrected before proceeding with the test.
- h. Prior to beginning any subtest, verify correct power source, necessary test instrumentation, and inter-connection cabling. Ensure that a minimum warmup period of at least 15 minutes has occurred, and that all input voltages and currents are adjusted to the value specified by the manufacturer.

6.2 TEST CONDUCT

6.2.1 Electromagnetic Field Pattern

- a. Perform electromagnetic field pattern measurements in accordance with the procedures given in MTP 6-2-020, Antenna Subsystem Tests.

6.2.2 Transmission Range

- a. Determine transmission ranges of the test item in accordance with the procedures contained in MTP 6-2-515, Transmitter Range Tests.

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6.2.3 Power Requirement

a. Perform power requirement tests in accordance with the procedures given in MTP 6-2-514, Electrical Power Requirements.

6.2.4 Power Supply

a. Perform power supply tests as indicated in applicable portions of MTP 6-2-210, Power Supply, Electrical.

6.2.5 Electromagnetic Vulnerability

a. Perform electromagnetic vulnerability tests in accordance with the procedures given in MTP 6-2-508, Electromagnetic Vulnerability.

6.2.6 Electromagnetic Compatibility

a. Perform electromagnetic compatibility tests in accordance with the procedures given in MTP 6-2-509, Electromagnetic Compatibility.

6.2.7 Spectrum Signature

a. Perform spectrum signature tests in accordance with the procedures contained in MIL-STD-449-C, Radio Frequency Spectrum Characteristics.

6.2.8 Frequency Accuracy and Stability

a. Determine the frequency accuracy and stability of the test item in accordance with the procedures given in MTP 6-2-517, Frequency Accuracy and Stability.

6.2.9 Interrogator Transmitter and Receiver

a. Subject the interrogator transmitter and receiver to the procedures given in MTP 6-2-242, Receiver-Transmitters, General.

6.2.10 Bench Tests

6.2.10.1 Voltage Test

a. Measure and record the several voltages between all test points and test item chassis (ground). Values shall be as listed in test item technical manual within the tolerance specified in applicable criteria or on wiring diagram.

6.2.10.2 Local Oscillator AFC Alignment

a. Connect the test item to a radar test set (or oscilloscope) as specified in the test item technical manual.

b. Energize equipment and after temperature stabilization, read local oscillator crystal current on test meter. Repeat at five minute intervals or until two successive readings are the same.

c. Record successive crystal current readings to the maximum steady state.

d. Detune local oscillator to 50 percent of maximum crystal current or until AFC indicator is actuated. Read crystal current at detuned point.

e. Record the following:

- 1) Amount (percent) of detuning required to actuate AFC indicator.
- 2) Comparative value of crystal current at maximum to that at the detuned point(s).

6.2.10.3 Pulse Length Discriminator

a. Connect the test item to a radar test set (or oscilloscope) as specified in the test item technical manual.

b. Energize equipment and after temperature stabilization, interrogate the test item and observe output on oscilloscope.

c. Adjust pulse width control on test set through its entire range, while observing the control scale reading and the cathode ray tube (CRT).

d. Record limits of pulse width at which a steady CRT reading can be observed and limits of pulse width which are marginal (intermittent CRT signal), but which are operationally acceptable.

6.2.10.4 Coder Check

a. Connect the test item to a radar test set (or oscilloscope) as specified in the test item technical manual.

b. Insert code elements in test unit

c. Energize equipment and after temperature stabilization, select switch combinations which will include all code elements while observing the CRT.

d. As each code combination is inserted, record the code observed on test set CRT.

e. Record the maximum number of code (code element) combinations.

6.2.10.5 Quartz Crystal Units

a. Using crystal testing instrumentation, verify that all crystal units meet the requirements of MIL-C-3098 and such additional criteria as may be prescribed in applicable QMR's or TC's.

b. Connect a frequency meter or counter to the test item antenna terminals, and install the crystals provided.

c. Energize equipment and allow the unit and crystal at least 15 minutes warmup time.

d. Place the test item in transmission and record the frequency delivered.

e. Repeat Steps (b), (c), and (d) above, for each crystal, as directed.

f. Record the following for each crystal tested:

- 1) Accuracy of crystal frequency
- 2) Stability of frequency controlled by each crystal
- 3) Stability and frequency range versus temperature (from environmental test).

6.2.10.6 Magnetron Current

a. Connect the test item to a radar test set (or oscilloscope) as specified in the test item technical manual.

b. Energize equipment and observe meter reading of magnetron current from turn-on until stability is reached.

c. Record time and value of magnetron current each minute.

6.2.10.7 System Sensitivity

a. Connect the test item to a radar test set (or oscilloscope) as specified in the test item technical manual.

b. Energize equipment, interrogate test item, and observe stability of the CRT display when the test set indicates normal operation.

c. Select a code-frequency combination, interrogate the test item, and vary the applied voltage from minus 10% to plus 10% while observing the effect on transmission continuity.

d. Record the following information:

- 1) Code-frequency combination
- 2) Applied test voltages
- 3) Limiting values at which skip-triggering occurs and ceases to occur.
- 4) Effect on transmission continuity as applied voltage is varied.

e. Repeat Steps (c) and (d) above, at least an additional four times, using a different code-frequency combination each time.

f. With the test item in readiness for transmission, select a new code-frequency combination and vary the pulse width of the interrogation signal from minus 50% to plus 50%, while observing the points of initiation and fallout of transmission on the CRT display (e.g., a nominal pulse width of 10 microseconds (μ sec.) would be tested from 5 to 15 μ sec, as the points of initiation and fallout of transmission are observed).

g. Record the following information:

- 1) Code-frequency combination
- 2) Interrogation pulse width at the points of initiation and fallout of transmission.
- 3) Limiting values at which skip-triggering occurs and ceases to occur.

h. Repeat Steps (f) and (g) above, at least an additional four times, using code-frequency combinations not previously used in Steps (c), (e), and (f) above, each time.

i. With the test item in readiness for transmission, select a new code-frequency combination and vary the pulse repetition frequency (PRF) from minus 10% to plus 10% while observing the points of initiation and fallout of transmission on the CRT display.

j. Record the following combination:

- 1) Code-frequency combination
- 2) PRF at the points of initiation and fallout of transmission
- 3) Limiting values at which skip-triggering occurs and ceases to occur.

k. Repeat Steps (i) and (j) above, at least an additional four times using code-frequency combinations not previously used in Steps (c), (e), (f), (h) and (i) above, each time.

l. With the test item in readiness for transmission, interrogate with a frequency one percent below the test item tuned frequency while observing the CRT display. If triggering does not occur, slowly raise the frequency until transmission begins.

m. Record the following information:

- 1) Frequency at which transmission begins
- 2) Limiting values at which skip-triggering occurs and ceases to occur.

n. Repeat Steps (l) and (m) above, at a frequency one percent above the test item tuned frequency.

o. If triggering occurs one percent away from the tuned frequency, repeat Steps (l), and (m), and (n) above, interrogating from two percent away from the tuned frequency.

6.2.10.8 Overall Check

a. Connect the test item to a radar test set as specified in the test item technical manual.

b. Connect a headset to the test set aural monitor jack and adjust volume to listening level. Disregard random noise.

c. Interrogate the test item and observe tone heard. If more than one tone appears, observe both.

d. Record tones heard and their duration. Indicate tone frequency.

6.2.11 Transponder Tests (Reference Figure 1)

6.2.11.1 Transponder Activation

6.2.11.1.1 Activation Device

a. Apply a simulated decoder output to the electronic switch input,

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and by means of a meter, oscilloscope, or lamp connected in series with the switch, observe action.

b. Record input value placed on the device in millivolts and the effect observed at the output terminals (go, no-go).

c. Repeat Step (a) decreasing the input signal by 5 percent until failure occurs.

d. Record decreasing input values in millivolts until device fails to produce an output and variations of observed output (go, no-go).

6.2.11.1.2 Oscillator

a. Connect a frequency meter or counter and wattmeter to the output of the transponder oscillator.

b. With the transponder and oscillator in operation, measure the output frequency and power over a 10 minute period.

c. Record the following:

- 1) Output frequency in Hertz
- 2) Stability of frequency during observation period in percent of drift
- 3) Maximum output power in milliwatts

d. Connect the modulator to the oscillator and repeat Steps (b) and (c), above.

6.2.11.1.3 Modulator

a. Connect a signal generator to the input of the modulator and an oscilloscope to the output terminals.

b. Apply to the modulator a variable amplitude signal accurately representing the quantity to be transmitted.

c. Vary the input signal between prescribed limits in at least 10 steps while observing the output on the oscilloscope. Include input levels one step beyond the prescribed limits.

d. Record modulator output (oscilloscope readings) versus applied input in the following format (Table I).

TABLE I. MODULATOR PERFORMANCE

<u>Input</u>	<u>(parameter transmitted)</u>	<u>Output</u>	<u>Differences</u>
1			
2			
3			
to			
10			

6.2.11.1.4 Coder

a. Connect an oscilloscope and meter to the output of the coder, and a signal generator and meter to the input of the modulator.

b. Apply at least 10 simulated modulated voltages (accurately representing the quantity to be transmitter) while observing the display on the oscilloscope for the following:

- 1) Uniformity of output
- 2) Accuracy of code
- 3) Comparison of code versus input

c. Record the following:

- 1) Series of signals applied through the modulator to the oscillator in millivolts
- 2) Series of signals subsequently impressed on the coder in millivolts
- 3) Coder output in the following format (See Table II).

TABLE II. CODER

Modulator Signal	Oscillator Signal	Coder Output Uniformity Accuracy Variations
1		
2		
3		
to		
10		

6.2.11.2 Coding System

6.2.11.2.1 Activation Code Test

- a. Set up the test item prepared for normal operation
- b. Set up a transmitting antenna at a distance beyond the far-field minimum, equal to D / λ or 3, whichever is larger.

Where:

D is the maximum aperture of the larger antenna
 λ is the wavelength at the design frequency of the test item

- c. Record the far-field dminimum range
- d. Modulate the transmitter in code and at tuned frequencies set on the test item receiver, while observing the output of the test item at its antenna terminals with a meter or oscilloscope. (Measurement of output power is not made at this time).
- e. Record power level triggering the test item.
- f. Maintaining the same power level (Step (e) above) at each tuned frequency, vary the testing transmitter frequency and observe response at that frequency. As the frequency varies about the fundamental, observe the limiting frequencies at which response occurs.
- g. Record presence or absence of triggering at frequencies other than fundamental.
- h. Increase the transmitter power to 10 watts and repeat Step (f) above, at five harmonic frequencies above the tuned fundamental and at three or more subharmonics.
 - i. At each harmonic and subharmonic using 10 watts power, record frequencies which trigger test item in the following format (See Table III).

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Table III. TEST ITEM TRIGGERING FREQUENCIES

Test Item Code and Frequency	Transmitter			
	Fundamental	1st Harmonic	2nd Harmonic	nth Harmonic
Fundamental/Code I				
Fundamental/Code II				
- - - /Code n				

Trigger Response of Test Item

(NOTE: Tabulation made for each test item frequency used)

6.2.11.2.2 Code Rejection Test

- a. Set up the transmitter with modulation designed for interrogation (triggering by coded signal).
- b. Transmit all code combinations, at each tunable frequency and code setting of the test item, a minimum of 10 times.
- c. Record responses as shown in Table IV

Table IV. FREQUENCY AND CODE RESPONSES

Test Item Frequency and Code	Transmitter			
	Code I	Code II	- -	Code n
Code I Frequency a. Frequency b. etc.				
Code II Frequency a. Frequency b. etc.				

NOTE: All code combinations shall be tested

6.2.11.2.3 Response Code

- a. Arrange the test item with a manual switch bypass of the transmit relay.
- b. Locate the receiver-indicator unit at a convenient distance.
- c. With the test item operating, open and close the manual switch a minimum of 10 times for each code provided in the test item while observing the signal transmitted.

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d. Record the observed transmission for each combination of frequency-code combinations, as indicated in Table V.

Table V. FREQUENCY-CODE COMBINATION (BOTH TEST ITEM AND TRANSMITTER)

Observation	Frequency Hz.	Code No.	Transmission (yes and no)
1 through 10			

e. Repeat Step (c) above, and record all mutually independent code elements.

6.2.11.2.4 Decoder Accuracy

- a. Connect an oscilloscope to the output of the decoder circuitry.
- b. Using the receiver and interrogator (or an independent, calibrated oscillator), deliver accurately coded inputs to the decoder while observing the output shown on the oscilloscope.
- c. Record the strength, duration, and stability of the observed outputs as indicated in Table VI.

Table VI. DECODER OUTPUT DATA

Transmission Code No.	Trial	Strength (in millivolts)	Duration (in millisec)	Stability (jitter)
I	1			
	2			
	3			
	4			
	5			
II	1			
	2			
etc.				

6.2.11.3 Triggering System

6.2.11.3.1 Trigger System

- a. Connect a radar test set to the test item as specified in the test item technical manual, or connect an oscilloscope to the output of the beacon transmitter.
- b. Trigger the test item a minimum of 20 on-off cycles while observing the response on the cathode ray tube (CRT).

- c. Record the reaction time and uniformity of response.
- d. Apply actual or simulated trigger signals through the receiver-decoder-switch circuitry. Record limits of input signal in millivolts.
- e. Vary the signal in frequency above and below nominal stated values while observing the response on the CRT.
- f. Record points of response skip triggering, pulse characteristics, and spacing at which the system skip-triggers or fails entirely.
- g. Repeat Steps (d), (e), and (f) for each variation in signal power level, pulse characteristics, and spacing.

6.2.11.3.2 Random triggering From Line Voltage

- a. Connect the test item to a radar test set (or oscilloscope) as specified in the test item technical manual.
- b. With the test item in readiness for transmission, vary the input line voltage from minus 10 percent to plus 10 percent while observing the response on the CRT.
- c. Record the variations of voltage and triggering of the beacon as line voltage is varied.
- d. Switch the line voltage on and off at short intervals and after periods of power on, while observing the response on the CRT. The short intervals shall vary from quick alteration of switching action to deliberate action at intervals of 5 seconds, 15 seconds, and 30 seconds.
- e. Record interruptions of voltage and triggering of the beacon resulting from switching action.

6.2.11.3.3 Random Triggering at Tuned Frequency

- a. Connect the test item to a radar test set (or oscilloscope) as specified in the test item technical manual.
- b. With the test item in operation, sweep the transmitter signal through all of the frequencies in the test item band at each tuned frequency capable of being set on the test item, while observing the response on the CRT.
- c. Record triggering observed during variations of transmitted frequency.
- d. Set the transmitter power at 10 watts and switch between "off" and "transmit" 10 times at the code and frequency setting of the test item, while observing the response on the CRT. Any combinations may be tested and shall be specified in the test plan.
- e. Record triggering observed during switching action of the transmitter.
- f. With the transmitter interrogating the test item, change the code setting to three other codes at random while observing the response on the CRT.
- g. Record triggering observed during switching of code settings.

6.2.11.3.4 Random Triggering-Extraneous Signals

- a. Throughout conduct of 6.2.11.3.2 and 6.2.11.3.3, closely observe for and record random triggering caused by signals that are not part of the tests.

b. Determine and record the test item's triggering response to electromagnetic signals of extraneous nature as prescribed in MTP 6-2-508, Electromagnetic Vulnerability.

6.2.11.4 Antenna Performance

- a. Arrange the test item for normal operation.
- b. Verify availability of prescribed power and circuit continuity.
- c. Place an interrogation unit or transmitter at a distance greater than the far-field minimum $\frac{D^2}{\lambda}$ or 3λ .

where:

D is the maximum aperture of the larger antenna
 λ is the test item design wavelength

- d. Record the far-field minimum distance in meters.
- e. Energize equipment and with the transmitter interrogating the test item, measure the test item antenna reception with an oscilloscope or meter.
- f. Adjust the transmitter to each transponder frequency, and vary the transmitted power from zero through normal output.
- g. Record values of received power as indicated in Table VII.
- h. Repeat Steps (e), (f), and (g) above, at both second and third harmonic frequencies.

Table VII. ANTENNA PERFORMANCE

(fundamental frequency)

Frequency (hertz)	0	0.1	0.2	0.5	0.7	0.9	1.0
1st							
2nd							
3rd							
thru all available frequency							

(Record data in watts received power)

6.2.12 Interrogation Subsystem

- a. With the transmitter, receiver, coder, and antenna system assembled as a unit, place a suitable test antenna (small dipole) 10 meters from the interrogator's antenna. Connect this antenna to a receiver of appropriate frequency bandwidth, and connect the output of the receiver's video stage to the input terminals of a wide band oscilloscope equipped with a recording camera and mount.

NOTE: The receiver should have first been calibrated by applying

various test signals to its input and observing the output values with a wide band VTVM. A calibrated curve of input signal versus output voltage should then be plotted.

b. Connect a VTVM to the input of the transmitter in such a manner that the trigger voltage to the transmitter can be measured. Supply the trigger voltage with a suitable power supply and switch.

c. Apply equipment power and allow a warm up and stabilization period.

d. Trigger the transmitter by applying pulses of appropriate amplitude and duration from the power supply. Measure and record the trigger voltage.

e. Adjust the oscilloscope to give a good, clean presentation, photograph the presentation, and record time base and vertical gain settings.

f. Switch the transmitter through all of its coding modes. Observe and record the time sequence, waveform, amplitude, and duration of the pulses on the oscilloscope display for each coding mode. Photograph the displays as in Step (e) above.

g. Reduce the trigger voltage 5 percent and repeat Steps (d), (e), and (f) above.

h. Repeat Step (g) above, until the transmitter will no longer trigger.

i. Reconnect the equipment as follows:

1) Connect a pre-checked out transponder to the test antenna.

2) Connect an oscilloscope to the transponder's output, in parallel with the test antenna.

3) If the interrogator-responsor is not already connected to its own display, provide one by connecting an oscilloscope to the output of the responsor and adjusting it to act as an A-scope.

j. Energize all equipment and allow a warm up and stablization period.

k. Activate the transponder reply mechanism, and observe the indication at the responsor display and at the transponder output. Photograph the displays of both oscilloscopes (or other indicators).

l. Repeat Steps (j) and (k) above, for each mode of operation of the transponder and interrogator-responsor.

m. Insert a variable attenuator between the transponder output and the oscilloscope.

n. Allow the equipment to again stabilize and while observing the oscilloscope display, decrease the signal strength with the variable attenuator by 5 percent of the value in Step (k) above.

o. Photograph the displays of both oscilloscopes (or other indicators), and repeat Step (l) above.

p. Repeat Step (o) above, until no indication is observed on the responsor indicator.

6.2.13 IFF System Tests

6.2.13.1 Multiple Interrogation

- a. Connect the item under test to a radar test set (or oscilloscope) as specified in the test item technical manual.
- b. Apply equipment power and by use of the receiver and interrogator (or an independent, calibrated oscillator), deliver an accurately coded frequency and power input trigger to the assembly.
- c. Record values of applied signal power and frequency in milliwatts and Hertz, as indicated in Table IX.
- d. Measure and record the transmitter, oscillator, modulator, and coder outputs as indicated in Table IX.
- e. Simultaneously apply two actual or simulated trigger signals, in synchronization through the receiver-decoder-switch circuitry and observe simultaneous performance of the coder and modulator in acceptance of the combined signals for transmission.
- f. Repeat Steps (c) and (d) above. Also record the composite output signal.
- g. Vary the time delay between the two input trigger signals and note skip-triggering and loss of response as a function of time delay between the trigger signals.
- h. Record the following information:
 - 1) Applied signal power and frequency.
 - 2) Transmitter, oscillator, modulator, and coder output power.
 - 3) Output signal of oscillator, modulator, and coder versus the desired composite.
 - 4) Trigger signal characteristics.
 - 5) Time delay in microseconds at which the system will skip-trigger or fail entirely.

6.2.13.2 Discrimination of Replies

- a. Select a suitable tracking range, instrumented in such a manner that aircraft positions with respect to ground may be determined exactly.
- b. Install transponders in two suitable aircraft and an interrogator-responsor on the tracking range. All equipment shall be mounted in its operational state.
- c. Energize all equipment in both the aircraft and ground system, and fly the two aircraft in side by side formation with minimum safe separation toward the ground interrogator-responsor.
- d. Fly repeated passes while interrogating the aircraft transponders, increasing the aircraft separation by 5 percent on each pass, until two separate indications are observed on the ground system responsor indicator.
- e. Record the aircraft separation distance, altitude, and the indicator response.
- f. Repeat Steps (d) and (e) above, with the aircraft flying one behind the other, starting at minimum safe separation, and increasing until separate indications are observed.

6.2.13.3 Reaction Time

- a. Connect a synchroscope to the interrogator-responsor of the item under test, in such a manner that it will operate as an A-scope, and an addi-

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tional synchroscope to the transponder so that both the received interro-gation and transmitted reply will be displayed.

b. Install the transponder in a suitable aircraft and energize all equipment. All equipment shall be mounted in its operational state.

c. Fly the aircraft toward the interrogation system while repeat-edly interrogating it.

d. Photograph the displays of both snychroscopes, and record the time base settings in microseconds/cm.

6.2.13.4 Sensitivity Time Control

a. Connect the item under test to a radar test set (or oscilloscope) as specified in the test item technical manual.

b. Apply equipment power and deliver an accurate power input signal to the responisor from the test set or normal transponder transmission.

c. With a db meter, measure and record the maximum received signal to the responisor.

d. Record the recovery time of the responisor indicator at the maximum power input level as measured with the oscilloscope.

e. Attenuate the input signal in even increments until there is no response at the responisor indicator. At each step, cycle the input signal on and off.

f. Measure and record the responisor recovery time at each attenuated power input, and the total available adjustment provided to secure optimum recovery cycles.

6.2.13.5 Traffic Capacity

a. Select a suitable tracking range, instrumented in such a manner that aircraft positions with respect to ground may be determined exactly.

b. Install ten transponder targets in suitable aircraft and two interrogator-responsors on the tracking range. Ensure that all equipment is mounted in its operational state.

c. Energize all equipment in both the aircraft and ground system, and within the limits of air traffic safety, fly the targets at the interro-gation system at random altitudes and directions.

d. Increase the number of targets one at a time until the system is saturated.

e. Record the maximum number of targets that can be querried by each system without saturation of the responisor indicator.

f. Trigger the transponders manually in a random manner.

g. Observe and record the effect of "fruiting" on each responisor indicator.

h. Note and record the effects on both the interrogator-responisor and transponder of the simultaneous arrival of replies or interrogations.

i. Determine and record the time lag between the time a transponder receives an interrogation and the time it can receive another, according to the method outlined in 6.2.13.3 .

6.3 TEST DATA

6.3.1 Preparation for Test

Data to be recorded prior to testing shall include but not be limited to:

- a. Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.
- b. Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.
- c. Damages to the test item(s) incurred during transit and/or manufacturing defects.

6.3.2 Test Conduct

Data to be recorded in addition to specific instructions listed below for each subtest shall include:

- a. Photographs or motion pictures (black and white or color), sketches, charts, graphs, or other pictorial or graphic presentations which will support test results or conclusions.
- b. An engineering logbook containing, in chronological order, pertinent remarks and observations which would aid in a subsequent analysis of the test data. This information may consist of temperatures, humidity, pressures, and other appropriate environmental data, or other description of equipment or components, and functions and deficiencies, as well as theoretical estimations, mathematical calculations, test conditions, intermittent or catastrophic failures, test parameters, etc., that were obtained during the test.
- c. Instrumentation or measurement system mean error stated accuracy.
- d. Test item sample size (number of measurement repetitions).

6.3.2.1 Electromagnetic Field Pattern

- a. Data shall be recorded in accordance with MTP 6-2-020.

6.3.2.2 Transmission Range

- a. Data shall be recorded in accordance with MTP 6-2-515

6.3.2.3 Power Requirement

- a. Data shall be recorded in accordance with MTP 6-2-514

6.3.2.4 Power Supply

- a. Data shall be recorded in accordance with MTP 6-2-210

6.3.2.5 Electromagnetic Vulnerability

- a. Data shall be recorded in accordance with MTP 6-2-508

6.3.2.6 Electromagnetic Compatability

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a. Data shall be recorded in accordance with MTP 6-2-509.

6.3.2.7 Spectrum Signature

a. Data shall be recorded in accordance with MIL-STD-449C.

6.3.2.8 Frequency Accuracy and Stability

a. Data shall be recorded in accordance with MTP 6-2-517.

6.3.2.9 Interrogator Transmitters and Receivers

a. Data shall be recorded in accordance with MTP 6-2-242.

6.3.2.10 Bench Tests

6.3.2.10.1 Voltage Tests

a. Record all voltages required for operation.

6.3.2.10.2 Local Oscillator AFC Alignment

a. Record successive current readings to the maximum steady state.

b. Record amount (%) of detuning to actuate AFC indicator.

c. Record comparative value of crystal current at maximum to that at the detuned point(s).

6.3.2.10.3 Pulse Length Discriminator

a. Record limits of pulse width at which steady CRT reading is observed.

b. Record limits of pulse width which are marginal by operationally acceptable.

6.3.2.10.4 Coder Check

a. Record code observed on CRT as each combination is inserted.

b. Record maximum number of code combinations that can be inserted.

6.3.2.10.5 Quartz Crystal Units

a. Record the following for each crystal tested:

1) Accuracy of crystal frequency

2) Stability of frequency

3) Stability and frequency range versus temperature.

6.3.2.10.6 Magnetron Current

a. Record time and value of magnetron current each minute.

6.3.2.10.7 System Sensitivity

- a. Record variations in CRT display of test item transmissions.
- b. Record code-frequency combinations used.
- c. Record applied test voltages and in each series, record effect on sensitivity.
- d. Record interrogation pulse widths and in each series, record those that mark initiation and fall-out of transmission.
- e. Record pulse rated frequency (prf) values and in each series, record those that mark initiation and fall-out of transmission.
- f. Record limiting values which produce skip-triggering.

6.3.2.10.8 Overall Check

- a. Record tones heard and their duration.
- b. Record tone frequency.

6.3.2.11 Transponder Tests

6.3.2.11.1 Transponder Activation

- a. Record the following data for the Activation Device Subtest:
 - 1) Input values placed on the device in millivolts.
 - 2) Observed effect at output terminals (go-no-go).
 - 3) Decreasing input values in millivolts until device fails to produce an output.
 - 4) Variations of output (go-no-go).
- b. Record the following data for the Oscillator Subtest:
 - 1) Output frequency in Hertz
 - 2) Stability of frequency in percent of drift
 - 3) Maximum output power in milliwatts
- c. Record the following data for the Modulator Subtest:
 - 1) Applied inputs
 - 2) Modulator outputs
- d. Record the following data for the Coder Subtest:
 - 1) Series of signals applied through modulator to the oscillator
 - 2) Signals subsequently impressed on the coder
 - 3) Coder outputs

6.3.2.11.2 Coding System

- a. Record the following data for the Activation Code Subtest:
 - 1) Far-field minimum range

- 2) Power level first triggering the test item.
 - 3) Presence or absence of triggering at frequencies other than fundamental.
 - 4) Frequencies which trigger test item using 10 watts power at each harmonic and subharmonic.
- b. Record the following data for the Code Rejection Subtest:
- 1) Data as prescribed in Table IV.
- c. Record the following data for the Response Code Subtest:
- 1) Observed transmission for each combination of frequency-coded combinations.
 - 2) All mutually independent code elements
- d. Record the following data for the Decoder Accuracy Subtest:
- 1) Output strength in millivolts
 - 2) Output duration in milliseconds
 - 3) Output stability (jitter)

6.2.3.11.3 Triggering System

- a. Record the following data for the Trigger System Subtest:
- 1) Reaction time and uniformity of response
 - 2) Input signal limits in millivolts
 - 3) Points of response skip-triggering
 - 4) Pulse characteristics
 - 5) Trigger spacing at which system will skip-trigger or fail entirely
 - 6) Bracket within which triggering is positive for frequency in Hertz power input in millivolts, pulse characteristics in micro seconds, and spacing.
- b. Record the following data for the Random Triggering from Line Voltage Subtest:
- 1) Variations of voltage
 - 2) Interruptions of voltage
 - 3) Triggering of beacon transmitter resulting from switching action.
- c. Record the following data for the Random Triggering at Tuned Frequency Subtest:
- 1) Triggering occurring during variations of transmitted frequency.
 - 2) Triggering occurring during switching action of the transmitter.
 - 3) Triggering occurring during switching of code settings.

d. Record the following data for the Random Triggering-Extraneous Signals Subtest:

- 1) Data in accordance with MTP 6-2-508
- 2) Triggering caused by signals that are not part of the tests

6.3.2.11.4 Antenna Performance

- a. Record far-field minimum distance in meters.
- b. Record values of received power for the fundamental, second, and third harmonics.

6.3.2.12 Interrogation Subsystem

- a. Record receiver calibration data as follows:

- 1) Signal strength in millivolts
- 2) Detector output in millivolts
- 3) Frequency at which calibrated

- b. Record trigger voltage.

c. Record time sequence, waveform, amplitude, duration of trigger pulses for each coding mode and percentage of applied trigger voltage.

d. Record the oscilloscope's time base setting in a usec/cm and the vertical gain settings in mV/cm.

e. Record the indicator's display for each mode of operation and percentage of output signal strength.

6.3.2.13 IFF System Tests

a. Record the following data for the Multiple Interrogation Subtest:

- 1) Applied signal power frequency.
- 2) Transmitter, oscillator, modulator, and coder output/power.
- 3) Output signal of oscillator, modulator, and coder versus desired composite.
- 4) Time delay in microseconds at which system skip-triggers or fails entirely.

b. Record the following data for the Discrimination of Replies Subtest:

- 1) Aircraft separation distance, altitude, and indicator response at instant of two separate indications.

c. Record the following data for the Reaction Time Subtest:

- 1) Time base settings in microseconds
- 2) The synchroscope displays shall be photographed

d. Record the following data for the Sensitivity Time Control Subtest:

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- 1) Maximum power of received signal
- 2) Recovery time of responder at maximum received power
- 3) Recovery times at attenuated inputs
- 4) Total available adjustment provided to secure optimum recovery cycles.

e. Record the following data for the Traffic Capacity Subtest:

- 1) Maximum number of targets that can be queried by each system without saturation.
- 2) Indicator response with respect to "fruiting", garbling, and target separation.
- 3) Effect on interrogator-responder and transponder with respect to simultaneous arrival of replies or interrogations.
- 4) Time lag between successive receptions of interrogations by the transponder.

6.4 DATA REDUCTION AND PRESENTATION

Processing of raw test data shall, in general consist of organizing, marking for identification and correlation, and grouping the test data according to subtest title.

Specific instructions for the reduction and presentation of individual test data are listed below.

6.4.1 Electromagnetic Field Pattern

Data taken in this subtest shall be reduced and presented as indicated in MTP 6-2-020.

6.4.2 Transmission Range

Data taken in this subtest shall be reduced and presented as indicated in MTP 6-2-515.

6.4.3 Power Requirement

Data taken in this subtest shall be reduced and presented as indicated in MTP 6-2-514.

6.4.4 Power Supply

Data taken in this subtest shall be reduced and presented as indicated in MTP 6-2-210.

6.4.5 Electromagnetic Vulnerability

Data taken in this subtest shall be reduced and presented as indicated in MTP 6-2-508.

6.4.6 Electromagnetic Compatibility

Data taken in this subtest shall be reduced and presented as indicated in MTP 6-2-509.

6.4.7 Spectrum Signature

Data taken in this subtest shall be reduced and presented as indicated in MIL-STD-449C.

6.4.8 Frequency Accuracy and Stability

Data taken in this subtest shall be reduced and presented as indicated in MTP 6-2-517.

6.4.9 Interrogator Transmitters and Receivers

Data taken in this subtest shall be reduced and presented as indicated in MTP 6-2-242.

6.4.10 Bench Tests

6.4.10.1 Voltage Test

Present nominal or prescribed voltages beside the corresponding measured values.

6.4.10.2 Local Oscillator AFC Alinement

- a. Present all current values for comparison during warm-up.
- b. Show percent cf detuning necessary to produce failure.
- c. Present maximum current versus current when detuned to produce failure.

6.4.10.3 Pulse Length Discriminator

- a. Present pulse width (length) which provides a steady response.
- b. Show and compare the above value with the greater pulse width (intermittent signal) still acceptable as taken from tolerance criteria applicable to the test item.

6.4.10.4 Coder Check

- a. Present total code combinations
- b. Display result of check with each combination

6.4.10.5 Quartz Crystal Units

- a. Reduce and present data in tabular form as shown in Table VIII.

Table VIII. QUARTZ CRYSTAL UNIT DATA

Crystal	Nominal Frequency	Test Frequency	Frequency Stability

6.4.10.6 Magnetron Current

- a. Present variation of current to stable condition, versus time.
- b. Compare the final value with that required, as taken from tolerance criteria applicable to the item under test.

6.4.10.7 System Sensitivity

- a. Display numerical variation between various CRT responses.
- b. Utilizing code-frequency combinations as fixed bases:
 - 1) Plot applied test voltage versus upper and lower limits of sensitivity (response).
 - 2) Plot applied prf versus upper and lower limits of sensitivity.
- c. Plot value found in Step (b) above, on a single graph showing values at which skip-trigger occur, versus the range of values tested.

6.4.10.8 Overall Check

- a. Enumerate the aural 1000 cycle tone as heard versus trigger impulses.
- b. Report other tones (e.g., 300 cycle) and time duration. Indicate interference if any.

6.4.11 Transponder Tests

6.4.11.1 Transponder Activation

6.4.11.1.1 Activation Device

- a. Compare and present the ability of the switch unit to accept the decoded signal and hold closed during required transmission.

6.4.11.1.2 Oscillator

- a. Evaluate the oscillator stability during all states of modulation.
- b. Compare output power with the theoretical power specified in

applicable specification.

- c. Evaluate variations of output when modulated by input data transmission.
- d. Evaluate effects on the above values when the modulator (input) is connected and operating.

6.4.11.1.3 Modulator

- a. Evaluate the ability of the modulator to deliver control signals equal in quality and accuracy to the input.

6.4.11.1.4 Coder

- a. Compare impressed signals with those delivered by the coder for consistency, uniformity, and absence of spurious content.

6.4.11.2 Coding System

6.4.11.2.1 Activation Code

- a. Reduce and present data as taken in accordance with paragraph 6.2.11.2.1.
- b. From repeated tests, compute the average and display the average number of responses (all power levels) versus frequencies other than the proper ones (transmitter and test item alike).

6.4.11.2.2 Code Rejection

- a. Tabulate data by frequency and code, noting unusual correlations, and plot rectangular coordinates to pinpoint failure to reject wrong codes at any point.

6.4.11.2.3 Response Code

- a. Plot data to show total responses of test item versus coded transmission and total failure to respond.

6.4.11.2.4 Decoder Accuracy

- a. Compute averages of each series of tests at similar inputs.
- b. Compare outputs for all responses to coded transmissions.
- c. Compare duration of output (activating) signal at each activation.
- d. Evaluate observed tendency to lose positive control of output signal (to hold the activation circuit closed).

6.4.11.3 Triggering System

6.4.11.3.1 Trigger System

- a. Present, in tabular form, the number of trials; number of accurate

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responses; and delays or failures of response.

b. Determine and present the upper and lower values of frequency power, pulse characteristics, and spacing that ensure transmission of the coded signal without skip-triggering.

c. When skip-triggering occurs, present the lower and upper limits at which skip-triggers occur a maximum of 80 percent.

6.4.11.3.2 Random Triggering from Line Voltage

a. Plot numbers of induced random responses versus cause as recorded in paragraph 6.2.11.3.2.

6.4.11.3.3 Random Triggering at Tuned Frequency

a. Plot numbers of random responses versus transmitted frequency.

6.4.11.3.4 Random Triggering-Extraneous Signals

a. Data taken in this subtest shall be reduced and presented as indicated in MTP 6-2-508.

6.4.11.4 Antenna Performance

a. From Tables I, VI, and VII add the recorded values to give total power accepted by the antenna.

b. Compute the proportion of the above power resident in the fundamental frequency, at each value of transmitted power.

c. Present the above computed values as the quality of the antenna to reject frequencies other than the fundamental, and also to discriminate between frequencies in the electromagnetic environment.

6.4.12 Interrogation Subsystem

a. Plot a graph of calibrated receiver input versus calibrated receiver output. This is to be used to make corrections of observed signal strength during the test.

b. Tabulate trigger voltage versus received response i.e., : If voltage triggered the transmitter.

c. Scale the oscilloscope photographs so that millivolts may be read from the ordinate and μ seconds from the abscissa. This is done by multiplying the measure value from the photograph in centimeters by the appropriate scale factor.

d. Determine the observed values of pulse amplitude, time sequence overshoot, risetime, sag, etc., and compare to the values specified.

e. Tabulate transponder reply signal strength versus indicator response. (response - no response).

6.4.13 IFF System Tests

6.4.13.1 Multiple Interrogation

a. Present system test data in tabular form for easy comparison of component when the test item is in normal full operation. (See Table IX).

Table IX. SYSTEM TEST VALUES

Input Power	Freq. (Hz)	Output Power	Oscillator Power	Modulator Power	Coder Power	Composite Power
					actual	desired

b. Evaluate the assembled data for regularity of change and agreement with requirements of military specifications.

c. Determine the upper and lower delay time values that ensure transmission without skip-triggering.

d. When skip-triggering occurs, present the lower and upper limits at which skip-triggers occur a maximum of 80 percent.

6.4.13.2 Discrimination of Replies

a. Tabulate aircraft separation in meters versus indicator response (i.e., one or two targets appear).

6.4.13.3 Reaction Time

a. Compare the reaction time values with those specified for the system.

6.4.13.4 Sensitivity Time Control

a. Present a narrative statement based on the series of tests indicating a theoretical number of transponders (targets) which the equipment will identify at short, medium, and long ranges.

6.4.13.5 Traffic Capacity

a. Compare the number of targets handled with the system specifications.

b. Determine if the effects of "fruiting" and other interference were excessive.

c. Compare the transponder's time lag with the system specifications.

A written report shall accompany all test data and shall consist of conclusions and recommendations drawn from test results. The test engineer's opinion, concerning the success or failure of any of the functions evaluated, shall also be included. In addition, equipment specifications that will serve as the model for a comparison of the actual test results should be included.

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Equipment evaluation usually will be limited to comparing the actual test results to the equipment specifications and the requirements as imposed by the intended usage. The results may also be compared to data gathered from previous tests of similar equipment, performed under similar conditions.

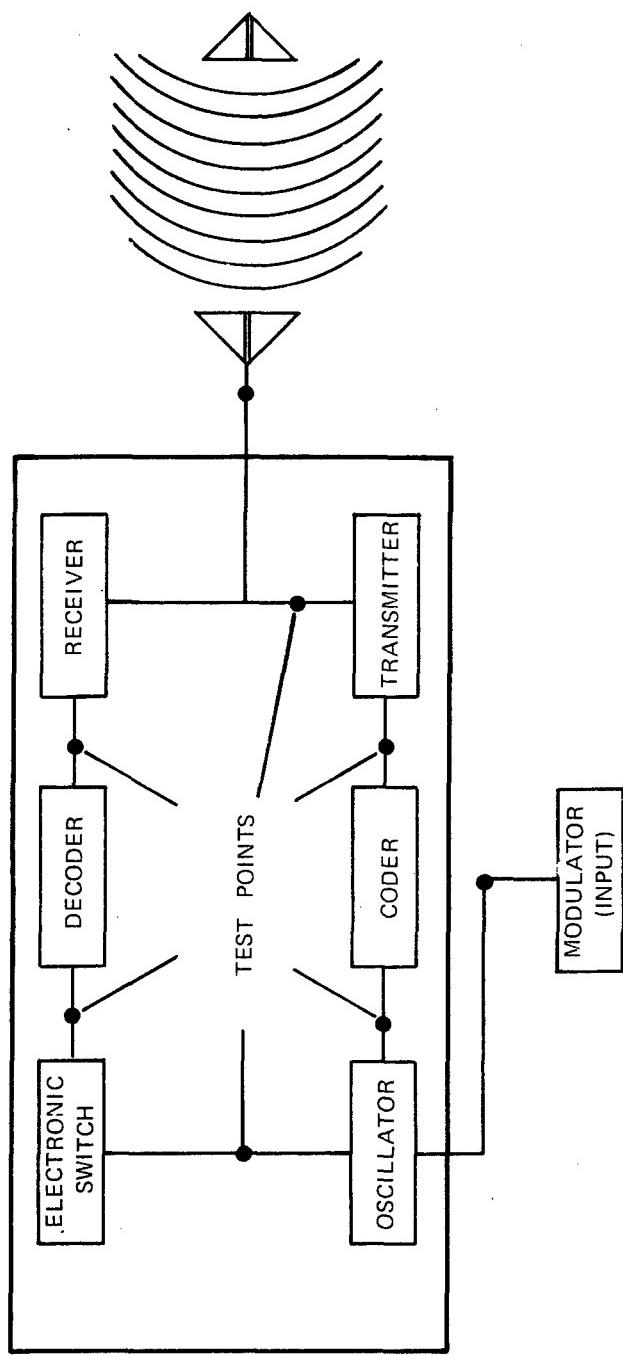


Figure 1—Transponder Component Diagram